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TITLE: DIAPHRAGM-LESS VACUUM BOOSTER

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# DIAPHRAGM-LESS VACUUM BOOSTER

## TECHNICAL FIELD OF THE INVENTION

This invention relates to vacuum brake boosters, and more particularly to a vacuum brake booster that does not use rolling diaphragms for sealing high and low pressure cavities within the booster from one another.

## BACKGROUND OF THE INVENTION

Vehicles such as automobiles, trucks, buses, and motor homes typically include a dashboard at the front of the passenger compartment, having a power brake booster on the front of the dashboard connected by a push rod to a brake pedal mounted on the rear of the dashboard in the passenger compartment. Such power brake boosters typically include a power piston that is sealed the inside of a booster housing by one or more rolling diaphragms. In some boosters having two or more diaphragms and a divider, forming a tandem brake booster, air passages or conduits must be provided to conduct air past the primary diaphragm. The use of rolling diaphragms, and air passages through the diaphragms creates certain disadvantages, and adds undesirable complexity and cost to the booster.

FIG.1 shows a typical prior tandem vacuum brake booster 100. The booster 100 includes a housing assembly 102, having a rear housing 104 adapted for connection to the front of the dashboard, and a front housing 106 adapted to receive and provide a mounting surface for a master cylinder 108 of the brake system. The housing assembly 102 of the vacuum booster 100 includes a divider 110 that divides the interior of the housing assembly into a primary chamber 112 and a secondary chamber 114, and provides sliding support for an axially movable booster power piston 116 that is connected via the push rod 118 to the brake pedal 120.

Extending radially outward from the power piston 116, in the secondary chamber 114 of the housing 102, is a secondary diaphragm support 122. In similar fashion, a primary diaphragm support 124 extends radially outward from the power piston 116 in the primary chamber 112. The primary and secondary diaphragm supports 122, 124 are fixed to the power piston 116 and move axially along an axis of motion 126 with the power piston 116.

A flexible rolling secondary diaphragm 128 has an outer periphery sealed to the inner walls of the secondary chamber 114 of the front housing 106, an inner periphery sealed to the power piston 116, and a skirt extending along the secondary diaphragm support 124 between the inner and outer peripheries of the secondary diaphragm 128, to thereby form a secondary low pressure chamber 130 between the secondary diaphragm 128 and the front wall 132 of the front housing 106 and a secondary high pressure chamber 134 between the secondary diaphragm 128 and the divider 110.

A flexible rolling primary diaphragm 136 has an outer periphery sealed to the inner wall of the primary chamber 112 of the rear housing 102, an inner periphery sealed to the power piston 116, an inner periphery sealed to the power piston 116, and a skirt extending between the inner and outer peripheries of the primary diaphragm 136, along the secondary diaphragm support 122, to thereby form a primary low pressure chamber 138 between the primary diaphragm 136 and the divider 110, and a primary high pressure chamber 140 between the primary diaphragm 136 and the rear wall 142 of the rear housing 102.

One or more air tubes 144 extend through the primary low pressure chamber 138 to connect the primary and secondary high pressure chambers 140, 134. The primary and secondary diaphragms 136, 128 include integrally formed grommets that provide a sliding seal between the air tubes 144 and the primary and secondary diaphragms 136, 128. The primary and secondary low pressure chambers 138, 130 are connected by holes 146 passing through the power piston 116.

The booster 100 includes valve elements, indicated generally by arrow 148, operably attached to the push rod 118 within the power piston 116, for selectively connecting all four chambers 138, 140, 130, 134 (i.e. the primary low pressure, secondary low pressure, primary high pressure, and secondary high pressure chambers) to a source of vacuum (not shown), such as the interior passages of an engine intake manifold, when the brake pedal 120 is not depressed. When the brake pedal 120 is depressed, the push rod 118 moves the valve elements 148 to a position where the primary and secondary low pressure chambers 138, 130 remain connected to the source of vacuum, but the primary and secondary high pressure chambers 140, 134 are connected to atmospheric air pressure around the brake booster 100.

The difference in pressure between the atmospheric pressure operating against the rear side of the primary and secondary diaphragms 136, 128, and the vacuum operating against the front side of the primary and secondary diaphragms 136, 128, generates a force against the primary and secondary diaphragm supports 124, 122 that drives the power piston 116 forward, (to the left in FIG. 1) and augments the force exerted through the push rod 118 from the brake pedal 120, acting through an internal booster output rod 150 in moving a hydraulic piston 152 in the master cylinder 108 to generate hydraulic pressure in the brake system for applying the brakes. The action of the brake booster 100 thus allows the pedal force required to generate a desired hydraulic pressure in the master cylinder 108 to be significantly less than the pedal force that would be required without the booster 100.

When the brake pedal 120 is released, after a braking event, a booster return spring 154 disposed between the front housing 106 and the power piston 116 causes the power piston 116 to move back to poise position, illustrated in FIG. 1. As the return spring 154 drives the power piston 116 back to the poise position, the valve elements 148 are momentarily positioned, as a result of the motion of the power piston and the action of springs within the valve elements, to allow the air in the primary and secondary high pressure chambers 140, 130 to escape through the valve elements 148. Once the air has escaped, the valve elements 148 return to a poised position, as shown in FIG. 1, that allows the primary and secondary high pressure chambers 140, 130 to be evacuated by the source of vacuum, to thereby equalize pressure across the primary and secondary diaphragms 136, 128.

Having the air tubes 144 pass through the divider 110, primary diaphragm 136, and primary diaphragm support 124, in order to allow sealed passage through the primary low pressure (vacuum) chamber 138 between the primary and secondary high pressure chambers140, 134, add significant undesirable complexity to the booster 100.

FIGS. 2a, 2b, and 3a, 3b illustrate a potential opportunity for enhancing performance the primary and secondary diaphragms 136, 128 respectively, in comparison to prior boosters. As shown in FIGS. 2a and 3a, air pressure within the primary high pressure chamber 134 fills the folded portions 156, 158 of the primary and secondary diaphragms 136, 128, with pressure acting on the interior of the folded portion 156 in such a manner that the effective area of the primary and secondary diaphragms 136,128 is less than the internal cross sectional area bounded by the inner surfaces 160, 162 of the booster housing 102.

Having the effective area of the primary and secondary diaphragms 136, 128 be less than the internal cross section of the booster housing 102, results in a reduction in the force that is generated by the power piston 116, or conversely, in the booster housing 102 having an outer diameter that is larger than would otherwise be required if the effective area equaled the internal cross sectional area of the booster housing 102. In a booster 100 of typical construction for a vehicle such as an automobile, having the effective diameter of the rolling diaphragm be less than the internal cross sectional are of the booster 100 results in a missed opportunity for generating additional assist force with the primary and secondary diaphragms 136, 128.

As shown in FIGS. 2b and 3b, rolling diaphragms present another disadvantage in that the folded portion 156, 158 of the primary and secondary diaphragms does not remain neatly folded, as shown in FIGS. 2a and 3a, as air is admitted into the primary and secondary high pressure chambers 140, 138. The folded portions 156, 158 of the diaphragms 136, 128 bulge around the edge of the primary and secondary diaphragm supports 124, 122, and try to form a cross section of the folded portions 156, 158 that is toroidal rather than folded. As the folded portions 156, 158 bulge around the diaphragm supports 124, 122, the net effect of the air pressure acting on the inside of the bulged folded portions 156, 158 generates a small undesirable force, on the diaphragm supports 124, 122, that acts to resist the desired motion and force of the power piston 116.

Large rolling diaphragms, having large thin wall sections, such as the primary and secondary diaphragms 136, 128 shown in FIGS. 1, 2a-2b, 3a-3b, are also difficult to manufacture. These diaphragms are typically fabricated from a rubber compound. Such rubber compounds inherently include hard particles of carbon black, that can result in localized weakness and tearing of the diaphragm in the area where the hard particles are located. Manufacturing procedures for rolling diaphragms made from rubber typically include filtration measures to reduce the presence of hard particles of carbon black, but experience has shown that even with filtration, it is difficult to produce rolling diaphragms with large thin wall sections in which the incidence of hard particles of carbon black is reduced to an acceptable level.

It is desirable, therefore, to provide a booster in which the effective area of the elements producing force on the booster power piston is equal to the internal cross sectional area of the booster housing. It is also desirable to provide a booster having an improved apparatus for conducting air between the primary and secondary high pressure chambers of a tandem vacuum brake booster. It is further desirable, to provide an improved booster that does not require rolling diaphragms.

SUMMARY OF THE INVENTION

The present invention provides an improved booster, meeting the requirements discussed above, through use of a power piston apparatus including a power piston operatively mounted within a booster housing for movement along a longitudinal axis of the booster, and having a sliding seal fixedly attached thereto for slidingly engaging a sealing surface of a annular wall of the booster housing for axially dividing the closed booster cavity into a high pressure cavity and a low pressure cavity.

In one form of the invention, the power piston apparatus includes an imperforate, generally annular, seal support flange extending radially outward from the power piston and defining an outer periphery thereof adapted for attachment of the sliding seal. The seal may be a lip seal.

One or more seal support flanges, according to the invention may be attached to the power piston for supporting either or both of a primary or a secondary seal. A second seal support flange, according to the invention, may include a generally annular shaped wall thereof having an outer surface in sliding sealing engagement with a sealing surface of the booster housing, a first end thereof attached to the power piston in the primary chamber, and an imperforate radially extending flange thereof attached to the opposite end of the annular shaped wall of the second seal support flange and extending radially outward to a distal peripheral edge thereof adapted for attachment of the second sliding seal.

A booster according to the present invention may also include a divider having an imperforate wall thereof fixedly attached and sealed to the booster housing and including a seal for sliding passage therethrough of the power piston, the divider dividing the closed cavity into a primary chamber and a secondary chamber, with a seal support flange dividing one of the primary or secondary chambers into a high pressure and a low pressure cavity thereof. The divider may include an annular wall thereof in the primary chamber, having a radially inward facing surface thereof forming a portion of the sealing surface of the housing in the primary chamber, and the housing may include an imperforate outer shell thereof spaced radially outward from the annular wall of the divider, to thereby form an air passage between the outer shell of the housing and the annular wall of the divider, the air passage providing fluid communication between a high pressure cavity of the primary chamber and a high pressure cavity of the secondary chamber. The divider may also include one or more imperforate formed notches at the

juncture of the axially facing wall and the annular wall of the divider, the one or more formed notches providing fluid communication between the air passage and a high pressure cavity of the secondary chamber.

The present invention may also take the form of a method for assembling a booster or power piston apparatus, according to the invention.

The foregoing and other features and advantages of the invention will become further apparent from the following detailed description of exemplary embodiments, read in conjunction with the accompanying drawings. The detailed description and drawings are merely illustrative of the invention rather than limiting, the scope of the invention being defined by the appended claims and equivalents thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross section of a prior vacuum brake booster having a rolling diaphragms and air tubes;

FIGS. 2a-2b, and 3a-3b are enlarged partial cross sections of the rolling diaphragms of the prior booster of FIG. 1;

FIG. 4 is a cross sectional view of a tandem vacuum booster according to an exemplary embodiment of the present invention, including primary and secondary sliding seals, instead of rolling diaphragms, and a convoluted divider forming an air passage between high pressure cavities within the booster, rather than air tubes;

FIG. 5 is perspective view of a divider, according to the invention,

FIG. 6 is an enlarged cross section of a portion of the booster of FIG. 4;

FIGS. 7 and 8 are enlarged cross sections of portions of the exemplary embodiment of FIG. 4; and

FIG. 9 is a cross section of an alternate embodiment of a secondary sliding seal support flange, according to the invention.

Throughout the following description of exemplary embodiments of the invention, components and features that are substantially equivalent or similar will be identified in the drawings by the same reference numerals. For the sake of brevity, once a particular element or function of the invention has been described in relation to one exemplary embodiment, the description and function will not be repeated for elements that are substantially equivalent or similar in form and/or function to the components previously described, in those instances where the alternate exemplary embodiments will be readily understood by those skilled in the art from a comparison of the drawings showing the various exemplary embodiments in light of the description of a previously presented embodiment.

DETAILED DESCRIPTION

FIG. 4 shows a first exemplary embodiment of the invention in the form of a tandem vacuum booster 10, including a booster housing 12 and a power piston apparatus 14.

The booster housing 12 includes a rear housing 16, adapted for attaching the booster 10 to a panel (not shown), a stepped front housing 18, adapted for attachment of a master cylinder (not shown), and a divider 20. The front and rear housings 18, 16 and the divider 20 are all joined and sealed from the environment at a common juncture 22 of the booster housing 12, using a multifunctional seal 23. The booster housing 12 defines a closed booster cavity 24, a longitudinal axis 26 of the booster 10, and a first and a second generally annular wall 28, 29 having first and second radially inward facing sealing surfaces 30, 32 thereof.

The first annular wall 28 and first radially inward facing sealing surface 30 are provided by an annular wall 28 of the divider 20. The annular wall 28 of the divider 20 is sealed to the housing 12 at the common juncture 22. As shown, in FIGS. 4 and 5, the divider also includes an imperforate axially facing wall 34 joined at a radially outer peripheral edge thereof to the annular wall 28 of the divider 20, at a point adjacent to the step 36 in the front housing 18, to thereby form a juncture 38 of the axially facing wall 34 with the annular wall 28 of the divider 20. The annular wall 34 of the divider 20 divides the internal cavity 24 of the booster housing 12 into a primary chamber 40 and a secondary chamber 42. The term imperforate, as used herein with respect to the divider 20, is intended to mean closed to the passage of air when the booster 10 is fully assembled. As shown, in FIGS. 4 and 5, the axially facing wall 34 of the divider 20 includes a central hole 44, adapted for attachment of a piston seal 46, for sliding passage therethrough of a power piston 48 of the power piston apparatus 14. As shown, in FIG. 5, the axially facing wall 34 also includes a pair of holes 50 spaced on either side of the central hole 44 for attachment of a tie rod seal (not shown) and passage of tie rods (not shown) for mounting the booster 10 to a panel and attaching the master cylinder to the booster 10.

The front housing 18 further includes an imperforate outer shell 52 thereof, spaced radially outward from the annular wall 28 of the divider 20, to thereby form an air passage 54 between the outer shell 52 of the housing 12 and the annular wall 28 of the divider 2. The air passage 54 provides fluid communication between a high pressure cavity of the primary chamber 40 and the high pressure cavity of the secondary chamber 42, in a manner described in more detail below.

As shown, in FIGS. 4, and 5 through 7 the power piston apparatus 14 includes a primary and a secondary, imperforate, generally annular, seal support flange 56, 58 extending radially outward from the power piston 48 and defining outer peripheries 60, 62 thereof adapted for attachment of primary and secondary sliding seals 64, 66, that seal the peripheries 60, 62 against the first and second sealing surfaces 30, 32 of the booster housing 12. The primary and secondary sliding seals 64, 66 are preferably low friction lip seals, but other types of seals may also be used.

The primary and secondary sliding seals 64, 66 shown in FIGS. 4, 6 and 9 can be fabricated with less concern over the presence of hard particles of carbon black, than was the case for rolling diaphragms having thin wall sections, because the sliding seals 64, 66 of the present invention do not include thin wall sections. The sliding seals 64, 66 of the present invention are more robust than rolling diaphragms, and have thicker cross sections that can tolerate higher percentages of hard particles of carbon black without being subject to the tearing sometimes experienced in the large, thin-walled, rolling diaphragms used in prior boosters.

As shown, in FIGS. 7 and 8, the primary and secondary seal support flanges 56, 58 each include a collar 68, 70 for attaching the seal support 56, 58 to the power piston 48 at the junctures of the seal supports 56, 58 and the power piston 48, and a seal 72 for sealing the juncture of each seal support flanges 56, 58 and the power piston 48. The seals 72 may take any appropriate form, such as the O-ring seal 72 shown in FIG. 8, or the flat washer-like seal 72 shown in FIG. 7. A retainer 74 may also be used for attaching the seals 72 and seal support flanges 56, 58 to the power piston 48.

In the same manner as described above with regard to the axially facing wall 34 of the divider 20, the term imperforate as used with respect to the primary and secondary seal support flanges 56, 58, means that once the booster 10 is assembled, the primary and secondary seal support flanges 56, 58 define a barrier to air flow. In embodiments of the invention including tie rods extending axially through the booster housing 12, for example, the seal support flanges 56, 58 may include holes (not shown) for passage of the tie rods. Such holes are slidingly sealed to the tie rods by sliding grommet-like seals installed into the holes in the primary and secondary seal support flanges 56, 58.

As shown, in FIG. 6, the primary seal support flange 56 divides the primary chamber 40 into a primary high pressure cavity 76 and a primary low pressure cavity 78. The secondary seal support flange 58 divides the secondary chamber 42 into a secondary high pressure cavity 80 and a secondary low pressure cavity 82.

As shown, in FIGS. 5 and 6, the divider 20 includes one or more imperforate formed notches 84 at the juncture 38 of the axially facing wall 34 and the annular wall 28 of the divider 20, and the annular wall 28 includes a series of slots 86 for the passage of air, from the primary high pressure cavity 76 to the secondary high pressure cavity 80. The formed notches 84 provide fluid communication between the air passage 54 and the secondary high pressure cavity 80.

The air passage 54 formed between the annular wall 28 of the divider 20 and the outer shell 52 eliminate the need for the air tubes 144 shown in the prior booster of FIG. 1. The sliding seals 64, 66 eliminate the need for the rolling diaphragms 128, 136 shown in FIGS. 1-3, and provide an effective area that is equal to the internal cross section of the booster 10 at the first and second sealing surfaces 30, 32. The sliding seals 64, 66 of the present invention thus allow a higher force to be generated with a booster 10 having the same internal dimensions of the sealing surfaces 30, 32 as the internal surfaces 160,

162 of the booster 100, or conversely would allow the outside dimensions of the booster 10 to be reduced for a booster that was only required to produce the same boost force as the prior booster 100.

Those skilled in the art will readily recognize that, while the embodiments of the invention disclosed herein are presently considered to be preferred, various changes and modifications can be made without departing from the spirit and scope of the invention. For example, the invention can be utilized in a tandem booster 100, as shown in FIG. 1, or in other types of single stage or tandem vacuum boosters.

FIG. 9 shows an alternate embodiment of a secondary seal support flange 58 including a generally annular shaped wall 88 thereof having an outer surface 90 adapted for sliding sealing engagement with the piston seal 46 in the divider 20, a collar 70 at a first end thereof adapted for attachment to the power piston 48 in the primary chamber 40, and an imperforate radially extending flange 92 thereof attached to the opposite end of the annular shaped wall 88 and extending radially outward to a distal peripheral edge 62 thereof adapted for attachment of the second sliding seal 66. The secondary seal support flange 58 of the embodiment shown in FIG. 9 thus allows a portion of the power piston 48 to be eliminated, and replaced by the annular wall 88 of the secondary seal support flange 58, to thus simplify and reduce the cost of the booster 10.

The scope of the invention is indicated in the appended claims, and all changes or modifications within the meaning and range of equivalents are intended to be embraced therein.